Contents

	Prețace		1X	
Part I. Intr	oductio	n	1	
	1. Mod	Models in Context		
	1.1	Complexity and Obscurity in Nature and in Models	3	
	1.2	Making the Connections: Data, Inference, and Decision	5	
	1.3	Two Elements of Models: Known and Unknown	13	
	1.4	Learning with Models: Hypotheses and Quantification	19	
	1.5	Estimation versus Forward Simulation	23	
	1.6	Statistical Pragmatism	24	
	2. Mode	el Elements: Application to Population Growth	27	
	2.1	A Model and Data Example	27	
	2.2	Model State and Time	30	
	2.3	Stochasticity for the Unknown	42	
	2.4	Additional Background on Process Models	4.1	
Part II. Ele	ments (of Inference	45	
4	3. Point	Estimation: Maximum Likelihood and the Method of Moments		
·	3.1	Introduction	47	
	3.2	Likelihood	47	
	3.3	A Binomial Model	53	
	3.4	Combining the Binomial and Exponential	54	
	3.5	Maximum Likelihood Estimates for the Normal Distribution	56	
	3.6	Population Growth	57	
	3.7	Application: Fecundity	60	
	3.8	Survival Analysis Using Maximum Likelihood	62	
	3.9	Design Matrixes	68	
	3.10	Numerical Methods for MLE	71	

	3.11	Moment Matching	71
	3.12	Common Sampling Distributions and Dispersion	74
		Assumptions and Next Steps	7 <i>€</i>
4	l. Elem	ents of the Bayesian Approach	77
	4.1		78
	4.2	The Normal Distribution	84
	4.3	Subjective Probability and the Role of the Prior	91
5	. Conf	idence Envelopes and Prediction Intervals	93
	5.1	Classical Interval Estimation	95
	5.2	Bayesian Credible Intervals	115
	5.3	Likelihood Profile for Multiple Parameters	120
	5.4	Confidence Intervals for Several Parameters: Linear Regression	122
	5.5	Which Confidence Envelope to Use	130
	5.6	Predictive Intervals	133
	5.7	· · · · · · · · · · · · · · · · · · ·	141
	5.8	When Is It Bayesian?	142
6	. Mod	el Assessment and Selection	143
	6.1	Using Statistics to Evaluate Models	143
		The Role of Hypothesis Tests	144
	6.3	Nested Models	144
	6.4		151
	6.5	•	154
	6.6	Additional Thoughts on Bayesian Model Assessment	159
Part III. Lar	ner M	ndels	161
r art III. Lui	yoi iiii	Juoi0	101
7	. Comj	outational Bayes: Introduction to Tools Simulation	163
	7.1	Simulation to Obtain the Posterior	163
	7.2	Some Basic Simulation Techniques	164
	7.3	Markov Chain Monte Carlo Simulation	173
	7.4	Application: Bayesian Analysis for Regression	189
	7.5	Using MCMC	202
	7.6	Computation for Bayesian Model Selection	205
	7.7	Priors on the Response	209
	7.8	The Basics Are Now Behind Us	212
8.	. A Clo	ser Look at Hierarchical Structures	213
	8.1	Hierarchical Models for Context	213
	8.2	Mixed and Generalized Linear Models	216
	8.3	Application: Growth Responses to CO ₂	230
	8.4	Thinking Conditionally	235
	8.5	Two Applications to Trees	241

	8.6		249
	8.7	From Simple Models to Graphs	249
Part IV. Mo	re Adv	ance Methods	251
n	. Time		
J.		W/I I T' I	252
	9.1 9.2	Why Is Time Important?	253
	9.2 9.3	Time Series Terminology Descriptive Florents of Time Series Models	254 255
	9.3 9.4	Descriptive Elements of Time Series Models The Frequency Domain	264
	9.5	Application: Detecting Density Dependence in Population	
		Time Series	264
	9.6	Bayesian State Space Models	272
	9.7	Application: Black Noddy on Heron Island	282
	9.8	Nonlinear State Space Models	289
	9.9	Lags Resime Change	297
	9.10 9.11	Regime Change Constraints on Time Series Data	298 300
	9.12	Additional Sources of Variablity	301
	9.13	Alternatives to the Gibbs Sampler	302
	9.14	More on Longitudinal Data Structures	302
	9.15	Intervention and Treatment Effects	309
	9.16	Capture-Recapture Studies	318
	9.17	Structured Models as Matrixes	329
	9.18	Structure as Systems of Difference Equations	336
	9.19	Time Series, Population Regulation, and Stochasticity	347
10.	Space	-Time	353
	10.1	A Deterministic Model for a Stochastic Spatial Process	354
	10.2	Classical Inference on Population Movement	359
	10.3	Island Biogeography and Metapopulations	378
	10.4	Estimation of Passive Dispersal	388
	10.5	A Bayesian Framework	397
	10.6	Models for Explicit Space	401
	10.7	Point-Referenced Data	403
	10.8	Block-Referenced Data and Misalignment	412
	10.9	Hierarchical Treatment of Space	415
	10.10	Application: A Spatio-Temporal Model of	
		Population Spread	424
	10.11	How to Handle Space	432
11.	Some	Concluding Perspectives	435
	11.1	Models, Data, and Decision	435
	11.2	The Promise of Graphical Models, Improved Algorithms, and	
		Faster Computers	437

viii • CONTENTS

11.3 Predictions and What to Do with Them	444	
11.4 Some Remarks on Software	456	
Appendix A Taylor Series	457	
Appendix B Some Notes on Differential and Difference Equations		
Appendix C Basic Matrix Algebra		
Appendix D Probability Models		
Appendix E Basic Life History Calculations		
Appendix F Common Distributions		
Appendix G Common Conjugate Likelihood-Prior Pairs	583	
References		
Index		